



An Energy Efficiency Workshop & Exposition

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Kansas City, Missouri

***Case Study: Analysis of Alternative  
Integrated Building Systems***

**SmithGroup**

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## q Conclusion

SmithGroup

- q A/FBO: Foreign Buildings Office
- q AEDG - Architecture and Engineering Design Guidelines for U.S. Diplomatic Buildings
- q SDS - Standard Delivery System
- q STM - Serviceability Tools & Methods
- q ABSIC - Advanced Building Systems Integration Consortium

## Background

- A/FBO: Responsible for managing design, construction & maintenance of chanceries
- Substantial expansion in new building program since 1998 aimed at improving Safety & Comfort of occupants
- SDS developed to streamline & effectively manage the project delivery process
- SDS aims to integrate & standardize appropriate levels of Design Criteria & Performance Requirements into the procurement process (AEDG, STM, Perspective™)
- Turned to ABSIC and CMU for academic assessment of current trends in workplace design criteria

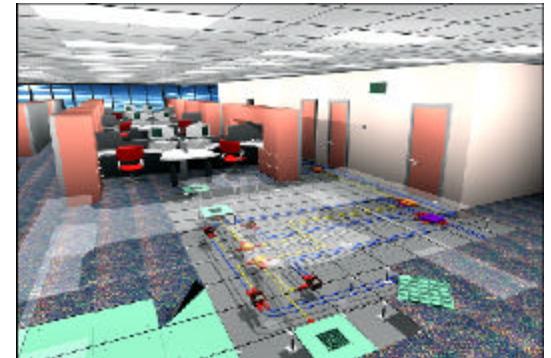




# ***Background-Performance Criteria***

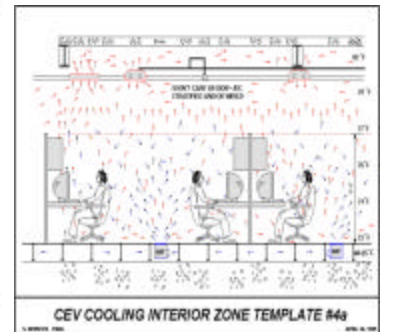
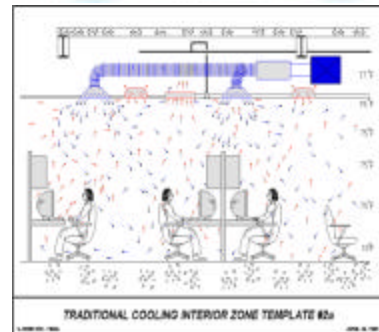
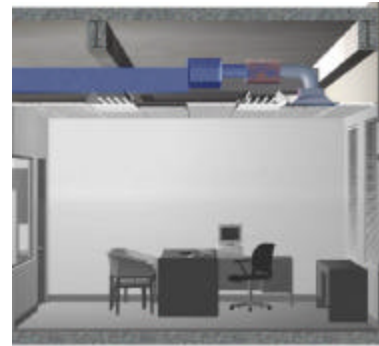
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- **Flexibility:** De-mountable partitions, modular furniture, ambient task lighting
- **Technology Ready:** Modular voice, data and power distribution systems, plug & play capability
- **Personal Comfort:** Thermal zoning - no more than one enclosed or three open offices
- **Improved IAQ:** ASHRAE Std 62-99
- **Energy Efficiency:** 10 CFR 435, ASHRAE 90.1-99
- **Life Cycle Cost Effectiveness**



## q Analysis

- Life-cycle cost (LCC) based analysis
- Two system concepts - conventional (ceiling-based) and floor-based
- Objective - to help FBO determine whether a specific system concept should be incorporated into SDS





## q Methodology

- Space Model
- Loads Model
- System Model
- Plant Model
- Economic Model



Courtesy of York Int'l



 **Mechanical Equipment Room**

 **Core**

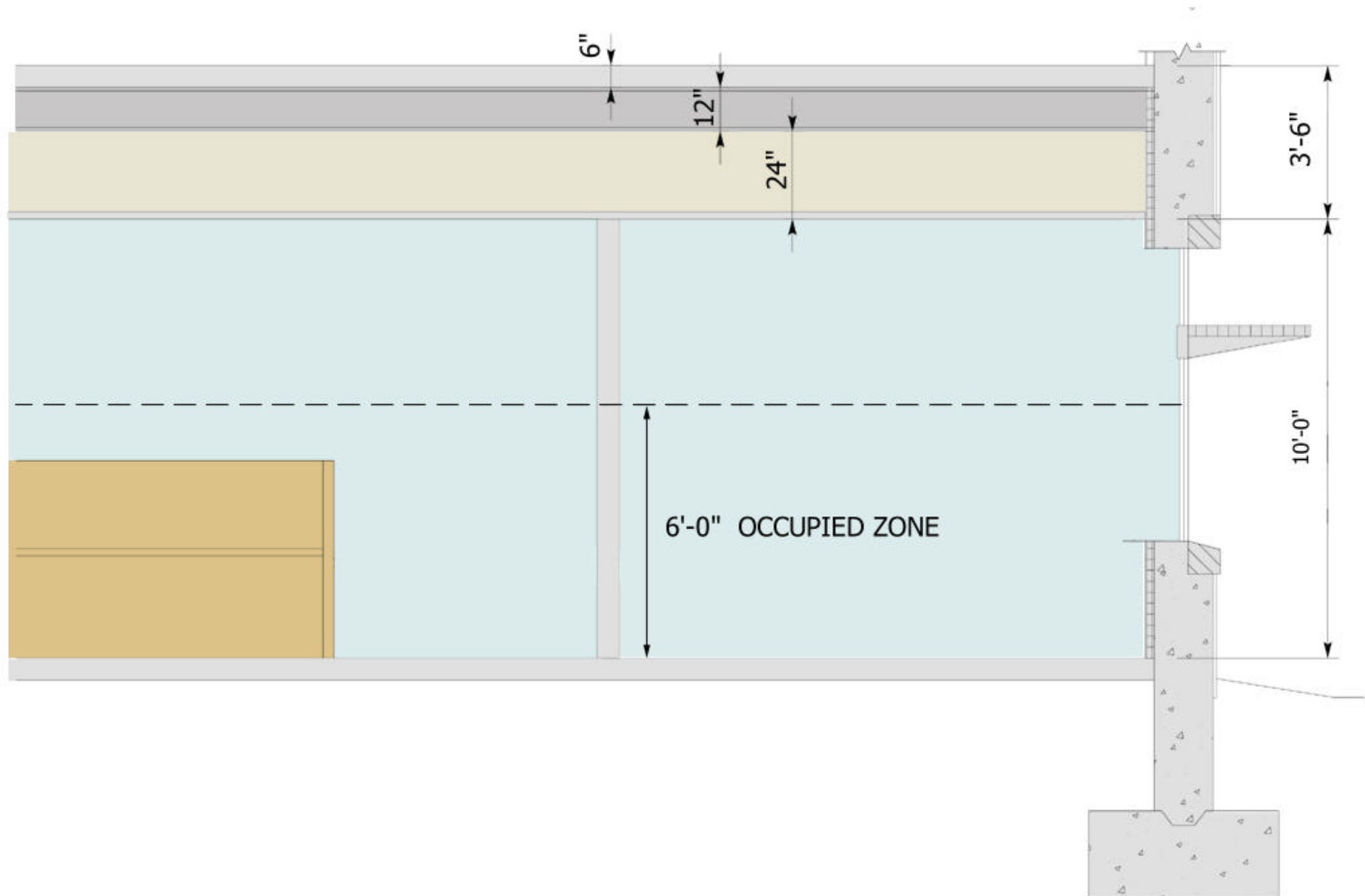
 **Conference Room**

 **Office**

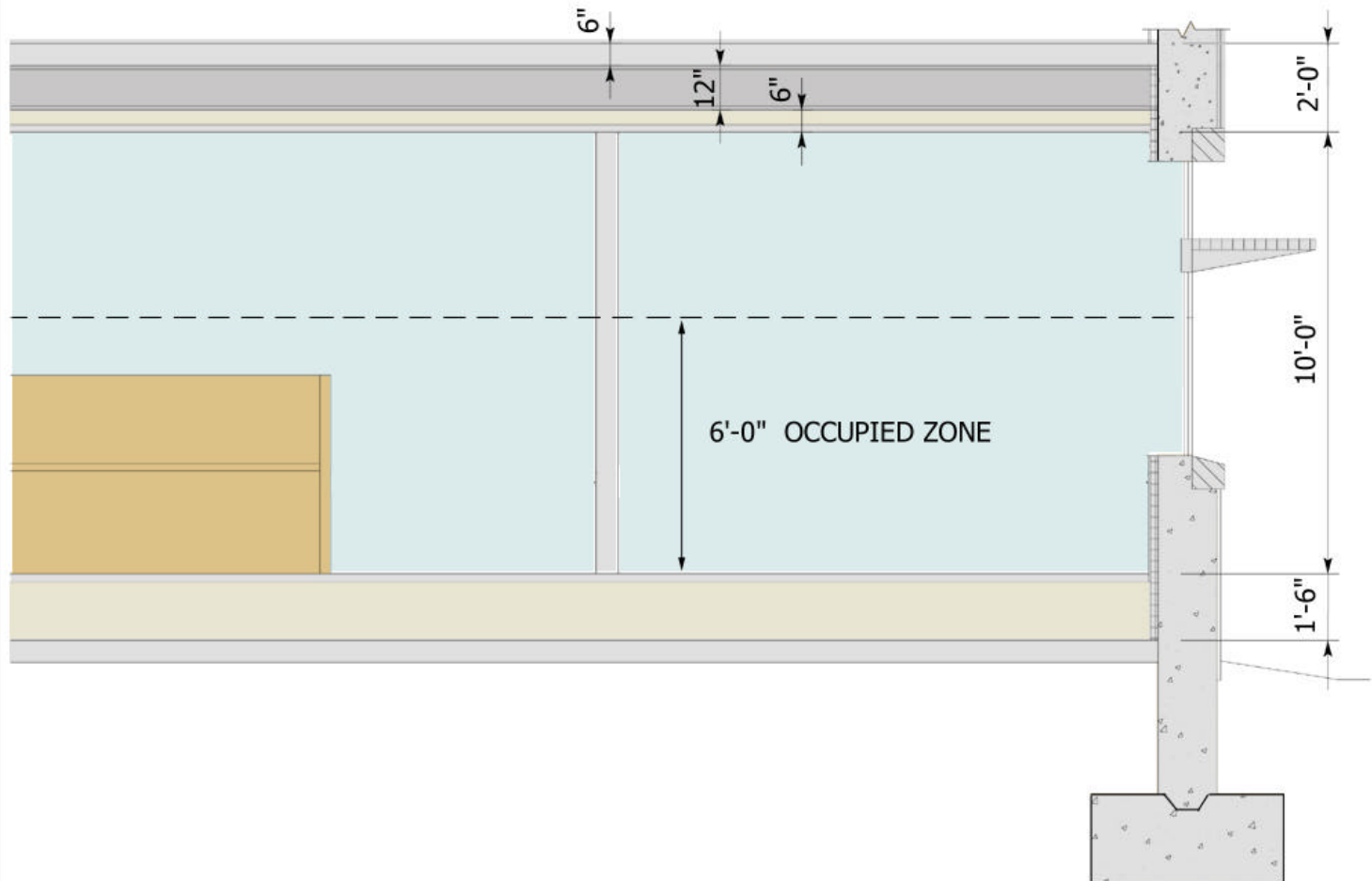
 **Primary Circulation**



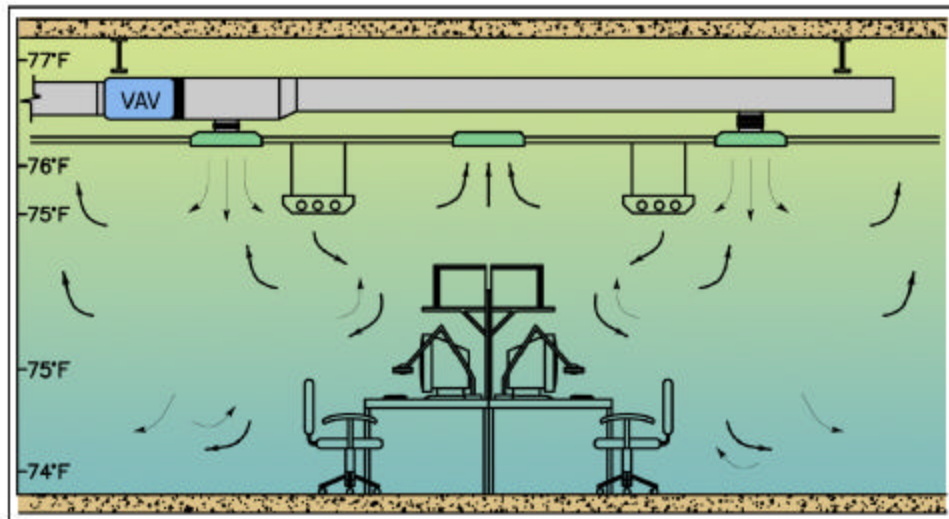
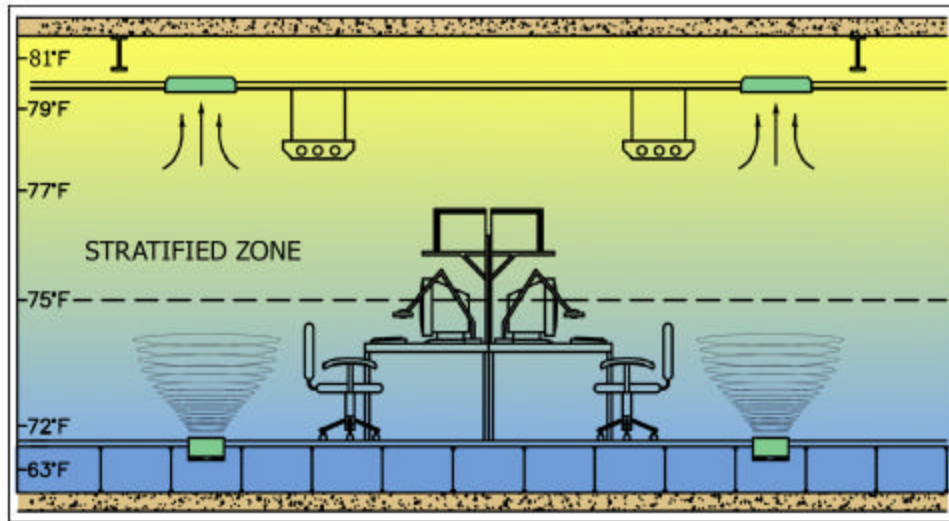
# *Methodology - Space Model*



# *Methodology - Space Model*



## *Methodology - Loads Model*

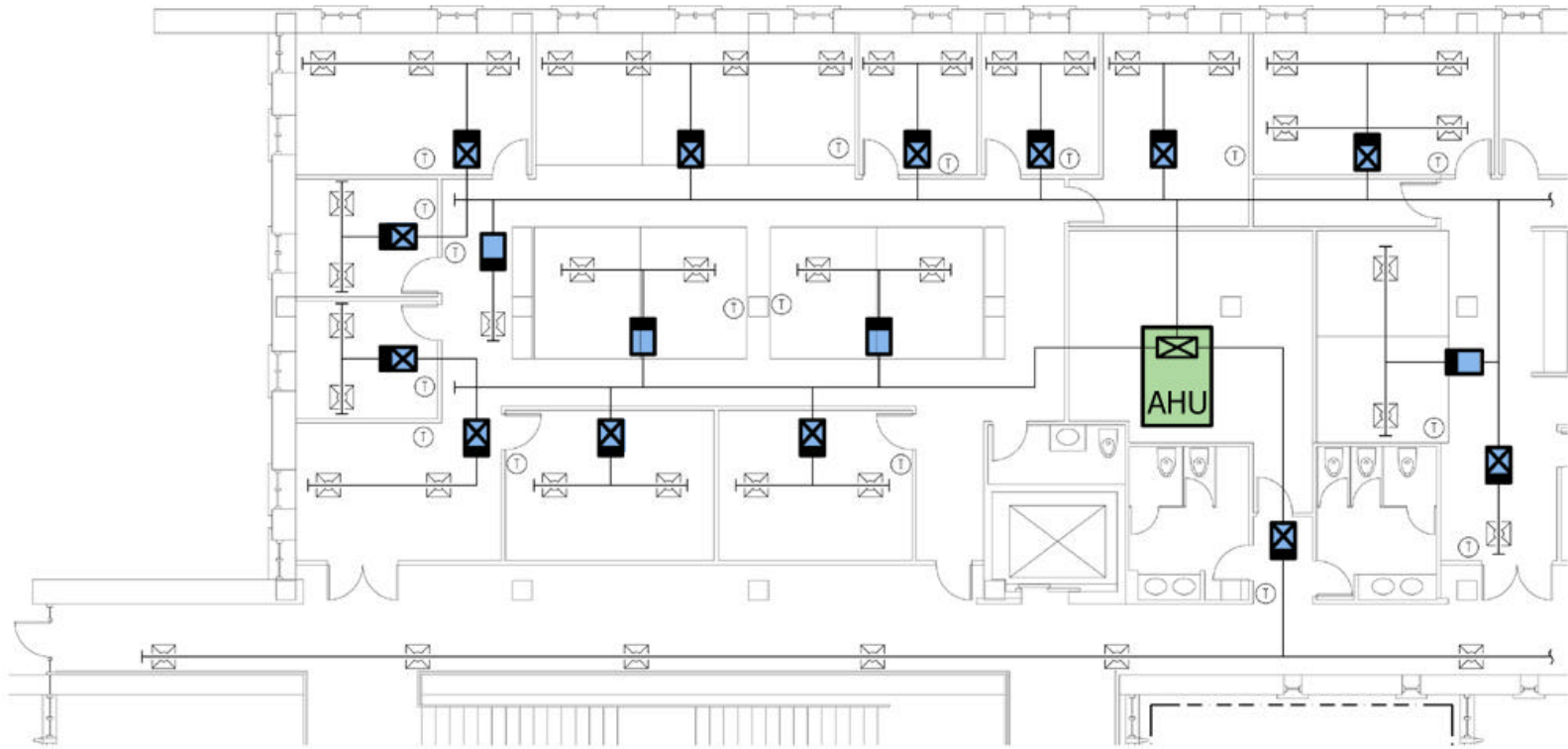


### ***Space Loads Comparison***



<b>Load Item</b>	<b>Conventional</b>	<b>Floor Based</b>
Lights	18.8 (100%)	<u>11.5</u> ( 61%)
People	4.6 (100%)	<u>3.3</u> ( 70%)
Plug Loads	26.8 (100%)	<u>18.8</u> ( 70%)
Glass Solar	5.2 (100%)	3.6 (100%)
Glass Conduction	2.3 (100%)	1.6 (100%)
Wall Conduction	2.7 (100%)	1.9 (100%)

(W/sq.m)

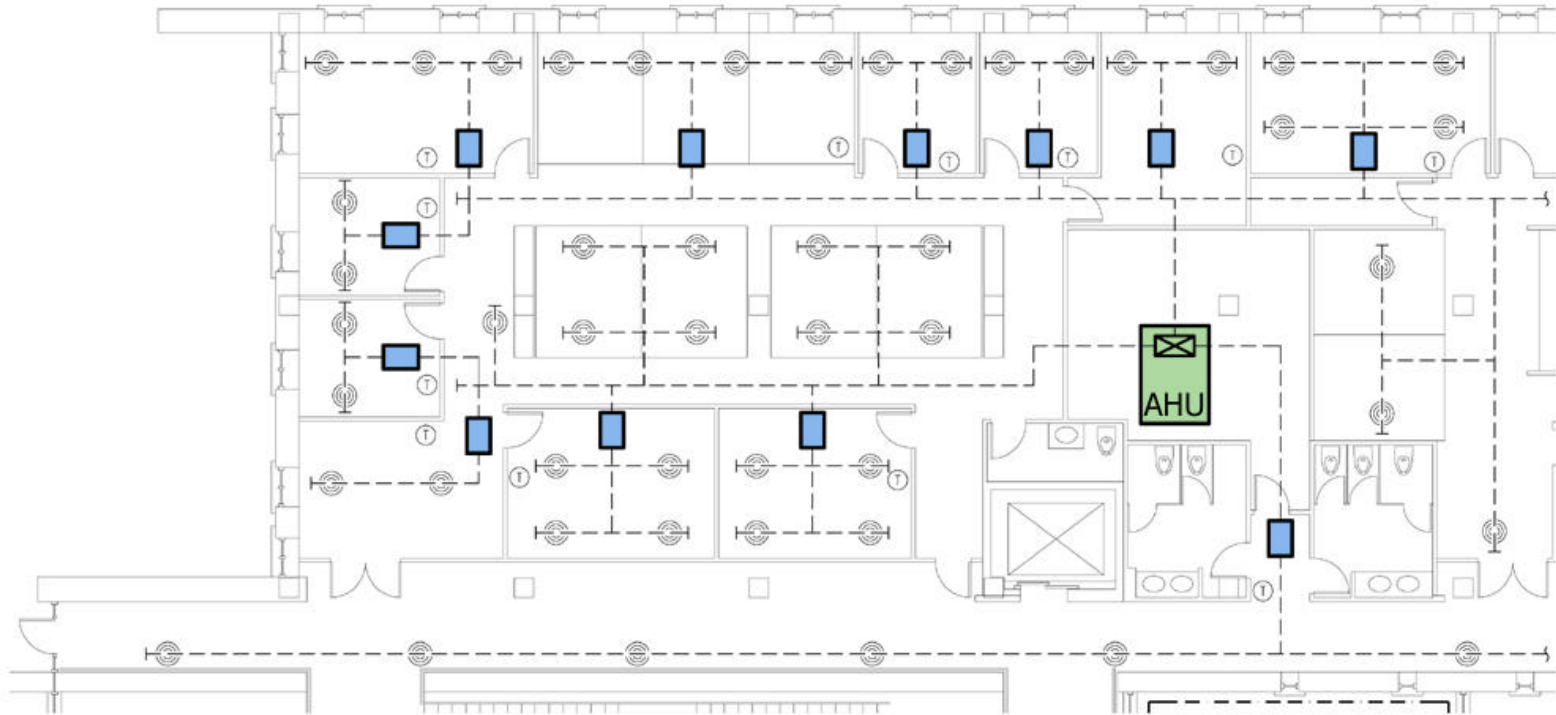
# Methodology - System Model



## LEGEND

-  VAV BOXES WITH REHEAT
-  SERIES FAN POWERED VAV BOXES

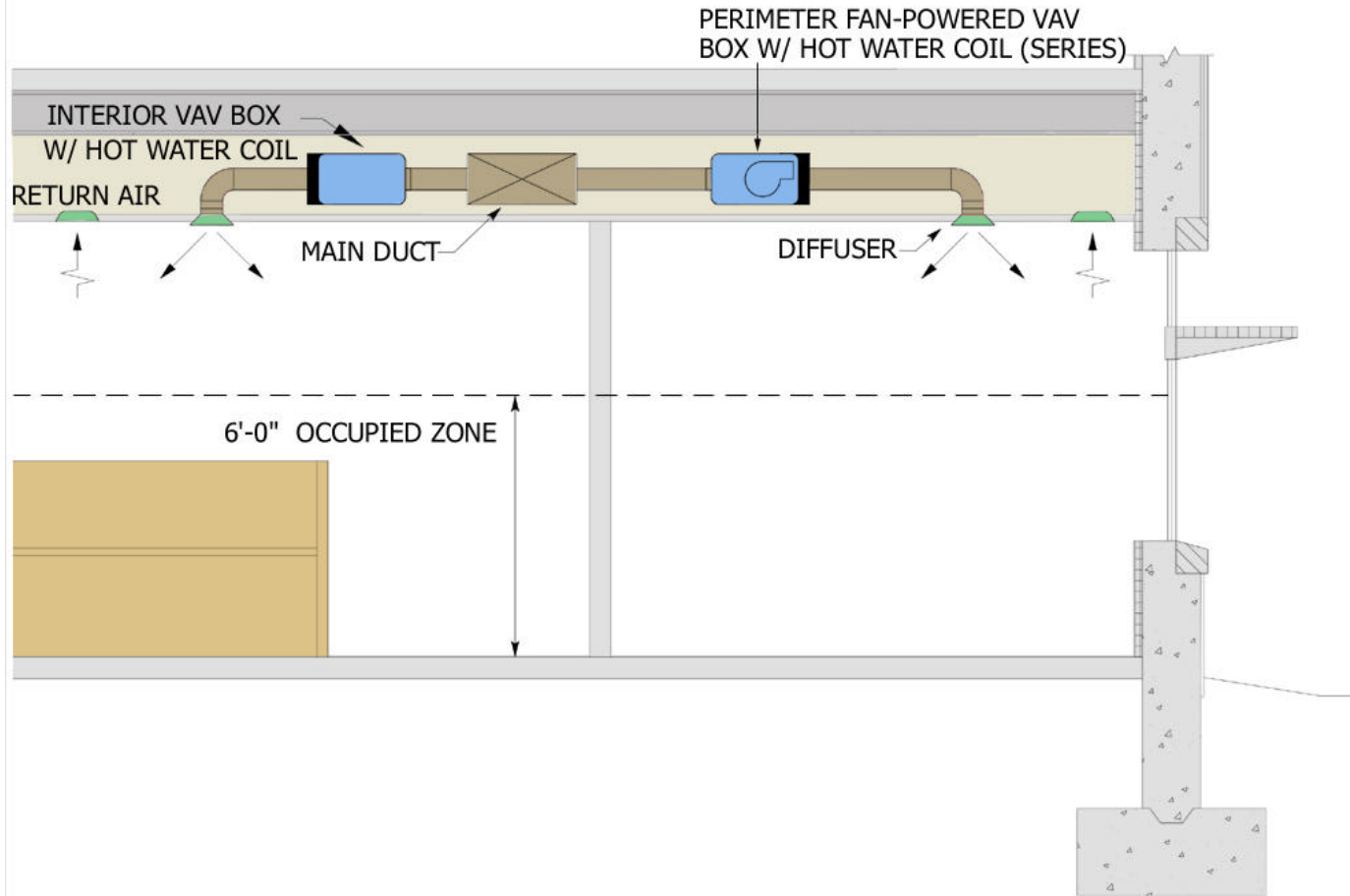
# *Methodology - System Model*



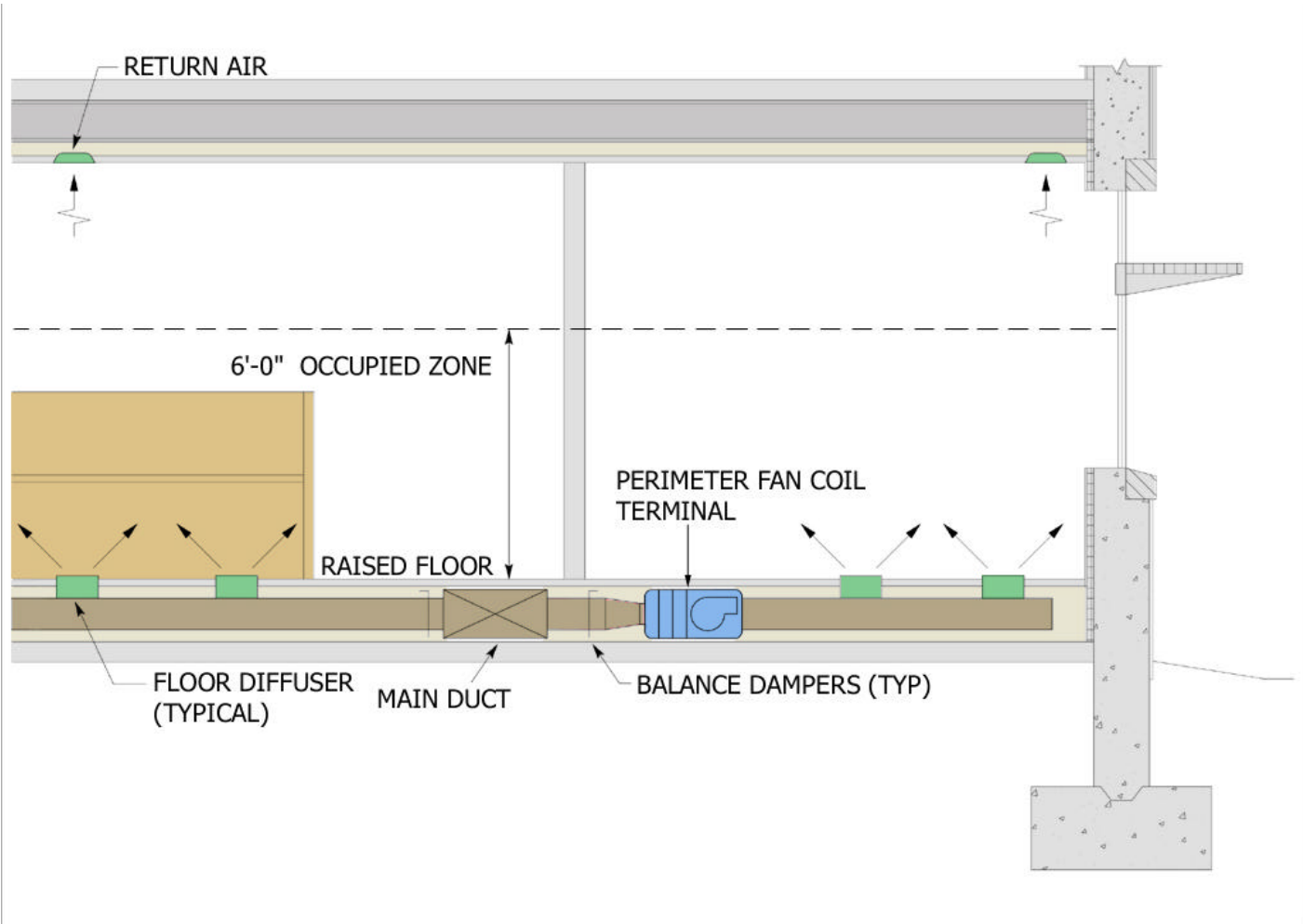
LEGEND  
■ FAN COIL UNIT



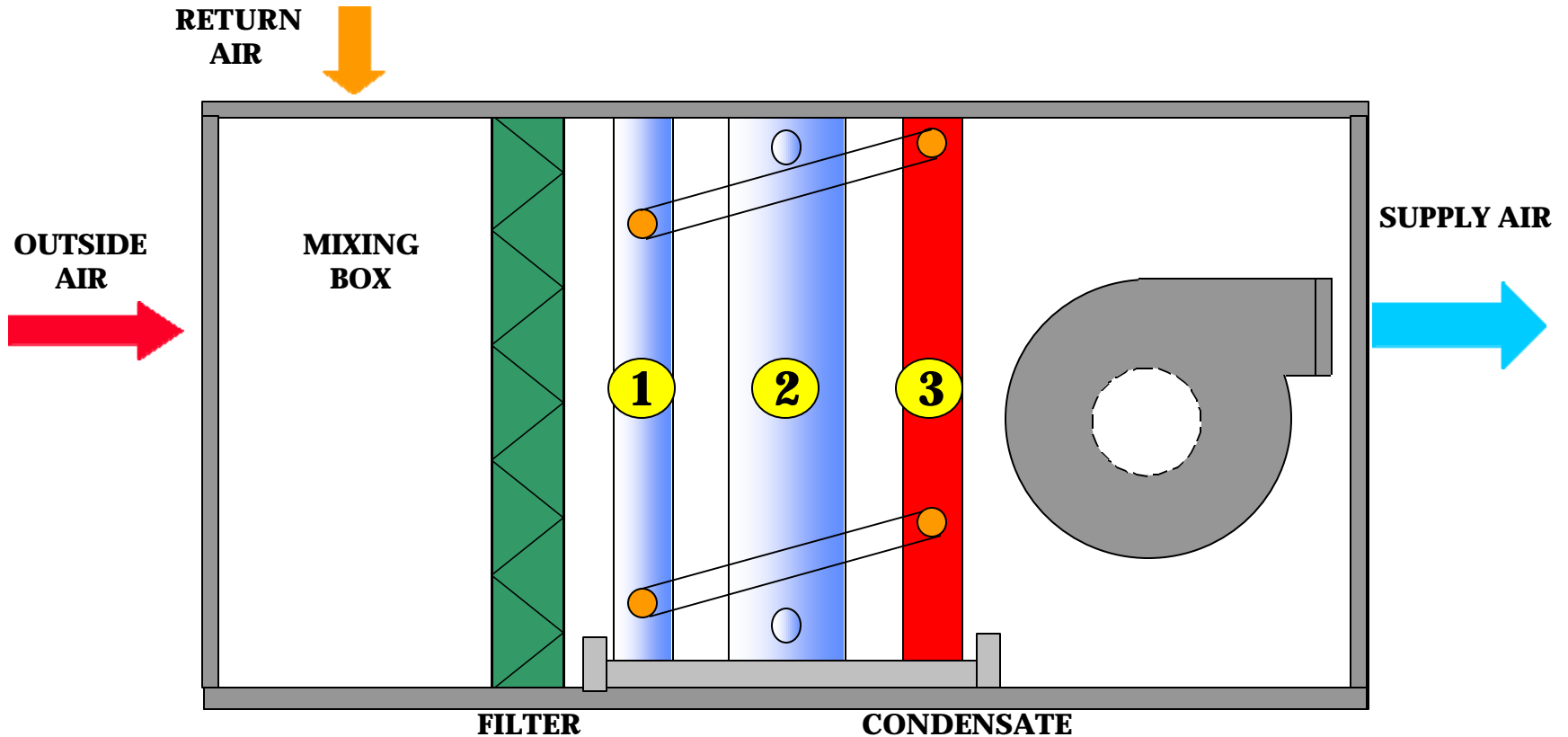
# *Methodology - System Model*



# *Methodology - System Model*



- q Central plant common to both
  - Air-cooled chiller
  - Dual-fuel hot water boiler
  
- q Floor-based AHU required modification to meet indoor design conditions
  - Sub-cooling and re-heating
  - Face and bypass cooling coil
  - Series heat recovery (runaround coils or heat pipes)

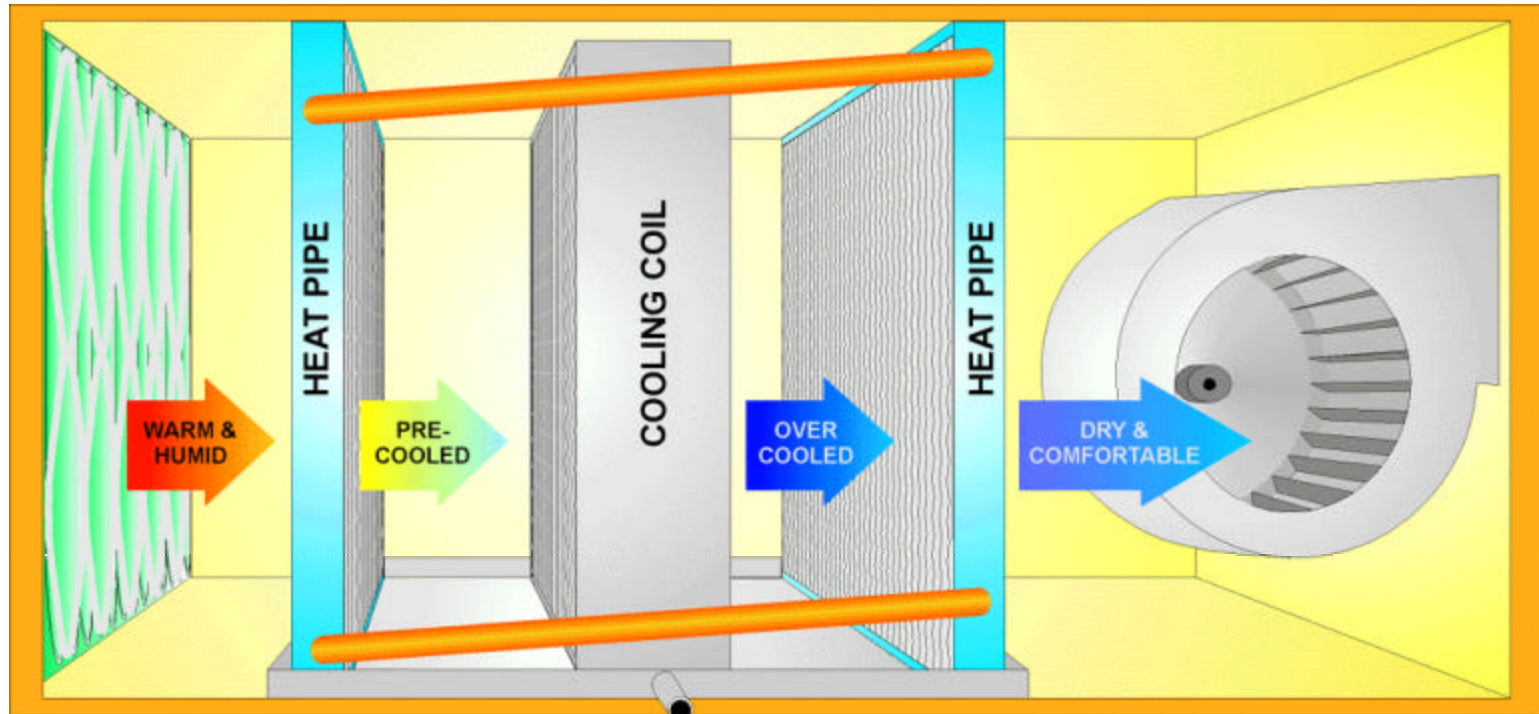


**① ENERGY RECOVERY PRE-COOLING COIL**

**③ ENERGY RECOVERY REHEAT COIL**

**② COOLING COIL**

## *Methodology - Plant Model*

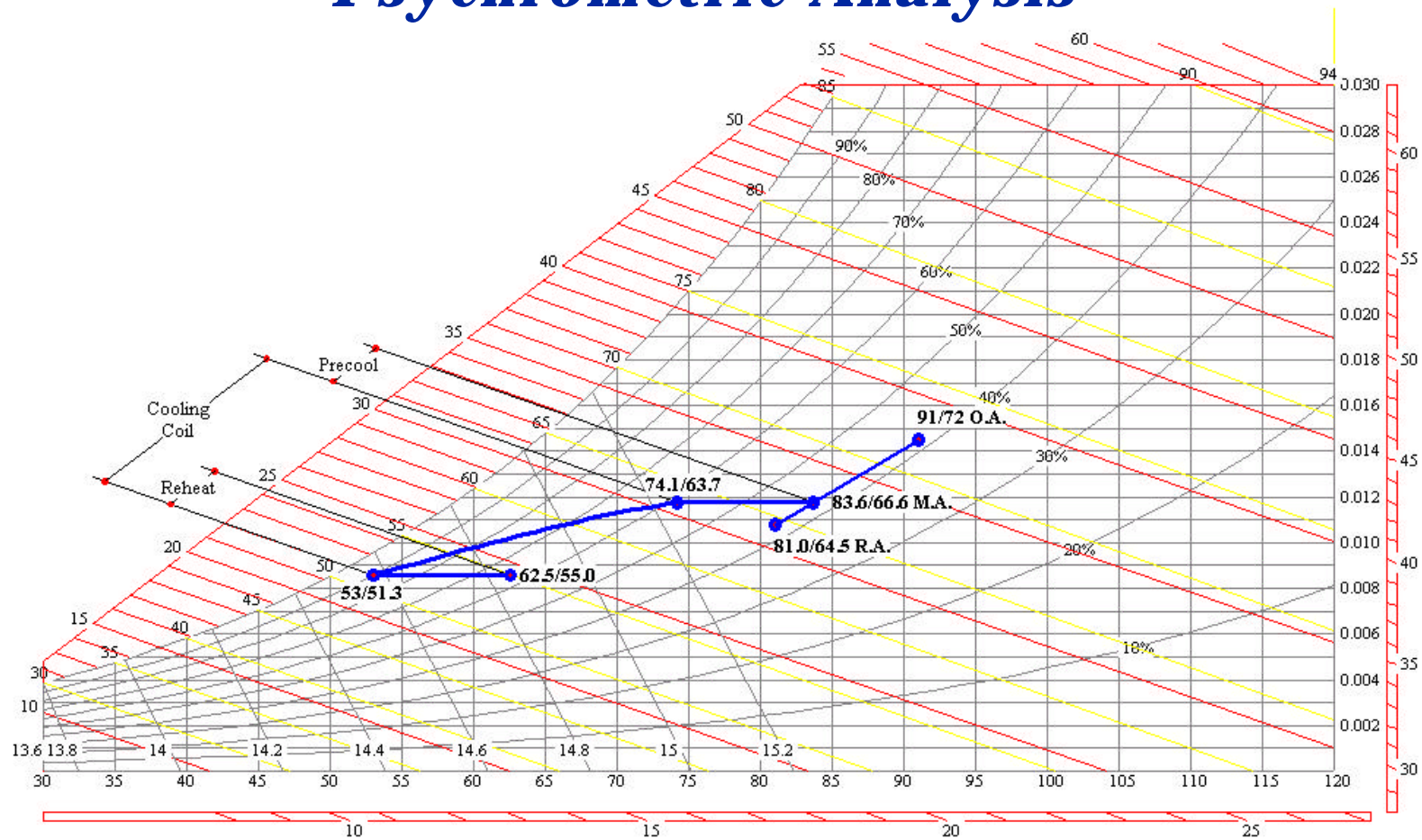


Courtesy of Heat Pipe Technology, Inc.



**Condensate**

## Psychrometric Analysis







## ***Results - Energy Analysis***

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### ***Equipment Capacity Comparison***

Item	Conventional	Floor Based
OA Airflow	1,910 cfm	1,895 cfm
OA Percent	21%	27%
Tot. Airflow	9,090 cfm	7,020 cfm
Cooling Load	24.3 tons	16.9 tons
Heating Load	253 Mbh	233 Mbh
Annual Energy	260,000 kWh	123,000 kWh



## ***Results - Economic Analysis***

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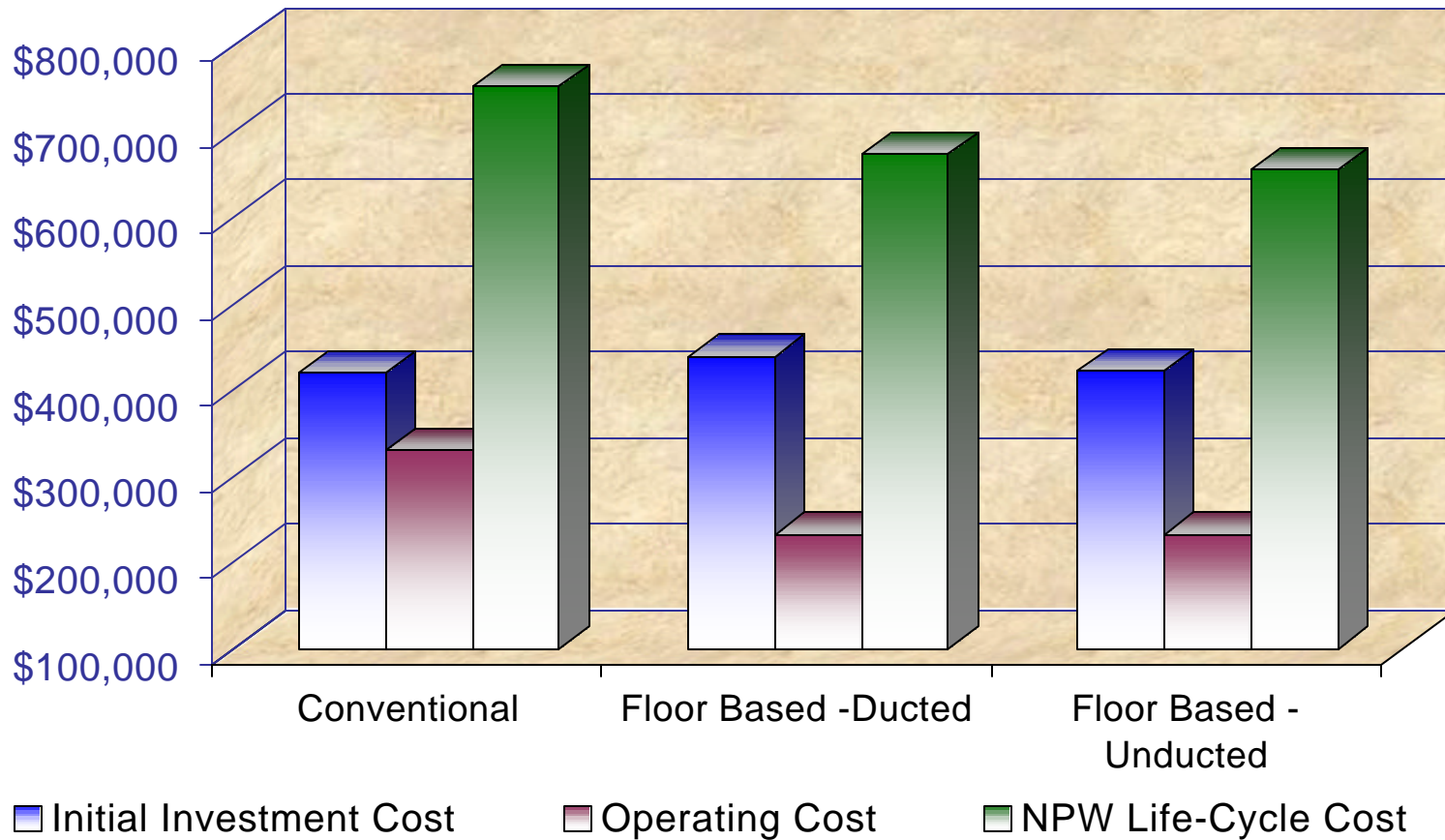
- q Costs developed using U.S. based cost estimates
- q Material costs increased by 20% to account for overseas shipping
- q Installation costs increased by 50% to reflect exported U.S. labor
- q Utility rates based on Mid-Atlantic region
- q Discount and fuel escalation rates based on DOE forecasts
- q LCC analysis performed using NIST BLCC program

## Results - Economic Analysis

### First Cost Comparison

Item	Conventional	Floor Based	
		Ducted	Un-
	ducted		
Raised Floor	-	\$74 / sm	\$74 / sm
Carpet	\$14 / sm	-	-
HVAC	\$336 / sm	\$279 / sm	\$253 / sm
Electrical	\$71 / sm	\$87 / sm	\$95 / sm
Total*	\$421 / sm	\$440 / sm	\$422 / sm

## Results - LCC Comparison



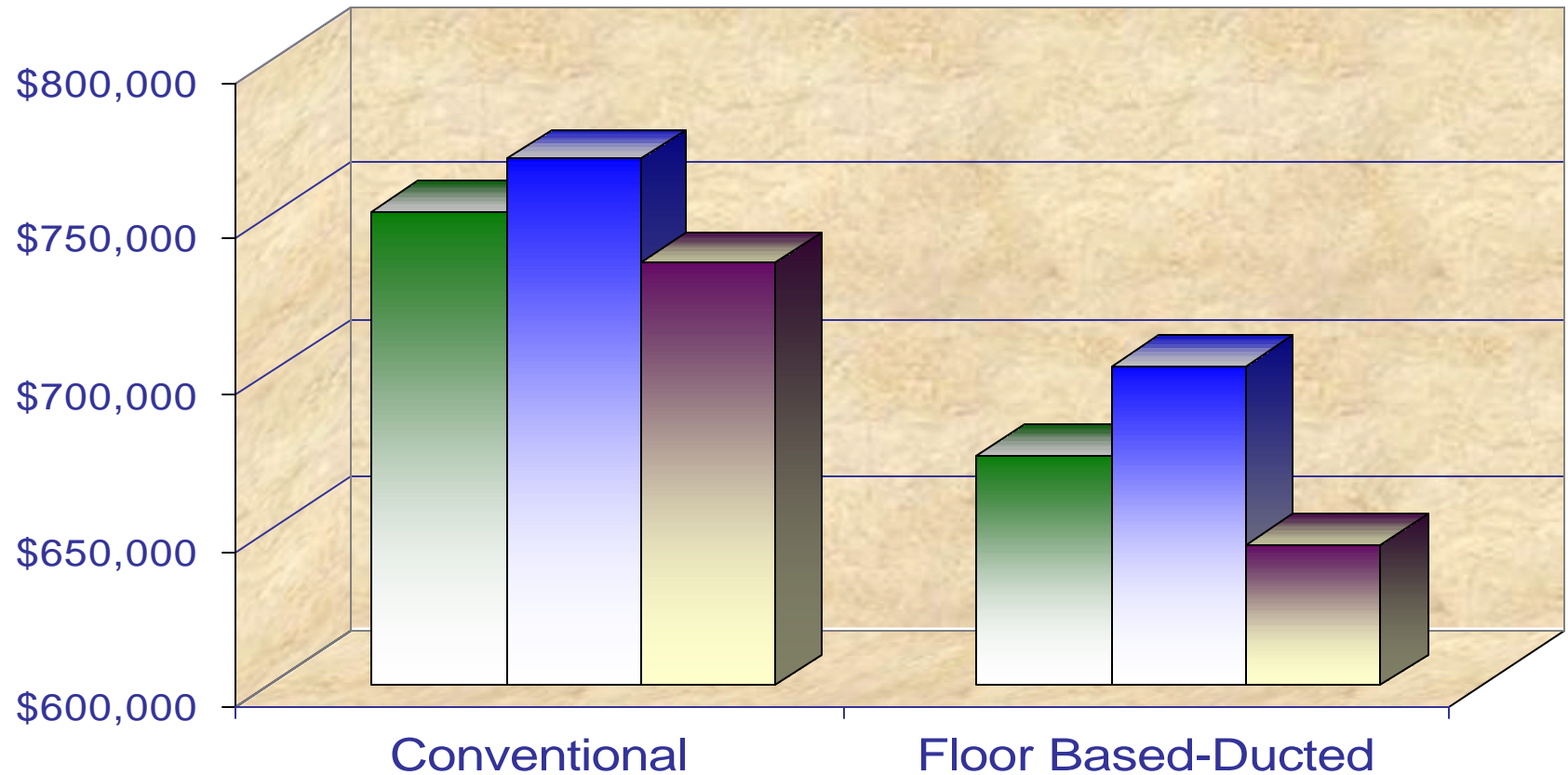


## ***Results - Economic Analysis***

### ***Life Cycle Cost Comparison***

<b>Item</b>	<b>Conventional</b>	<b>Floor Based</b>	
		<b>Ducted</b>	<b>Un-</b>
	<b>ducted</b>		
Initial	\$420,830	\$440,000	\$422,653
Operation	\$16,101	\$9,962	\$9,962
Maintenance	\$4,607	\$4,742	\$4,742
NPW	\$751,528	\$673,335	\$656,078
Svngs/Init'l	-	4	52
Spl. Payback	-	3.1 yrs	0.3 yrs

## Results - Sensitivity Analysis



■ Base ■ +10% Initial \$, -10% Energy \$ ■ -10% Initial \$, +10% Energy \$



q Productivity



q The LEED™ Rating System



q Flexibility and churn



# ***Additional Considerations - Churn***

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## ***Churn Cost Data***

- **BOMA 1998 Experience Exchange Report**
  - Simple moves to and from existing workplaces  
Average cost \$191 per move
  - Moves that include the relocation of furniture  
Average cost \$712 per move
  - Moves that require construction  
Average cost \$2100 per move
- q **IFMA Benchmarks II Survey:**
  - Average cost = \$1063 per employee (\$54/sq.m )
  - 41% of employees are relocated every year (\$22/sq.m-yr.)



## ***Additional Considerations - Churn***

### ***Estimated Churn Costs per Sq.m. of affected area***

<b>Item</b>		<b>Traditional</b>	<b>Floor Based</b>	<b>Savings</b>
<b>Electrical</b>	<b>Material</b>	<b>\$9.8</b>	<b>\$2.8</b>	<b>\$7</b>
	<b>Labor</b>	<b>\$8.5</b>	<b>\$0.0</b>	<b>\$8.5</b>
	<b>Total</b>	<b>\$18.3</b>	<b>\$2.8</b>	<b>\$15.5</b>
<b>Voice/Data</b>	<b>Material</b>	<b>\$5.6</b>	<b>\$3.2</b>	<b>\$2.4</b>
	<b>Labor</b>	<b>\$5.1</b>	<b>\$0.0</b>	<b>\$5.1</b>
	<b>Total</b>	<b>\$10.7</b>	<b>\$3.2</b>	<b>\$8.5</b>
<b>HVAC</b>	<b>Material</b>	<b>\$11.5</b>	<b>\$0.9</b>	<b>\$10.6</b>
	<b>Labor</b>	<b>\$13</b>	<b>\$0.0</b>	<b>\$13</b>
	<b>Total</b>	<b>\$24.5</b>	<b>\$0.9</b>	<b>\$23.6</b>
<b>Total</b>		<b>\$53.5</b>	<b>\$6.9</b>	<b>\$46.6</b>



- q Concerns with slab condensation in raised floor applications
- q Smoke detection in raised floor plenum
- q Ability to detect water under floor
- q Maintenance and cleanliness of air distribution system
- q Floor drains for accidental sprinkler system discharge
- q Space temperature gradient
- q Seismic Consideration

## q Summary of results

- Overhead alternative: Slightly lower initial cost
- Floor based distribution:



- Lower life cycle cost
- Better IAQ and ventilation effectiveness
- Flexible and easy to change by space occupant
- Recognized by USGBC as “Green”
- More comfortable than traditional systems



## q Key Considerations

- Perform similar analysis to gauge the influence of performance criteria, “spec office” or “build to suit”
- Integrate raised floor plenum (12-18 inch) without increasing overall building height
- Right sizing of HVAC equipment, assignment of space and coil loads
- Monitor supply air temperature and Relative Humidity
- Special attention to perimeter & Assembly spaces (FPVAV, VAVRH, MZ, fan coil)
- Building Construction: slab and building envelope







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***Thank You !!!***

[www.energy2001.ee.doe.gov](http://www.energy2001.ee.doe.gov)

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